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PROFESSIONAL AND TECHNICAL MANPOWER REQUIREMENTS AND SUPPLIES IN THE MICROELECTRONICS INDUSTRY IN ONTARIO : 1981-85

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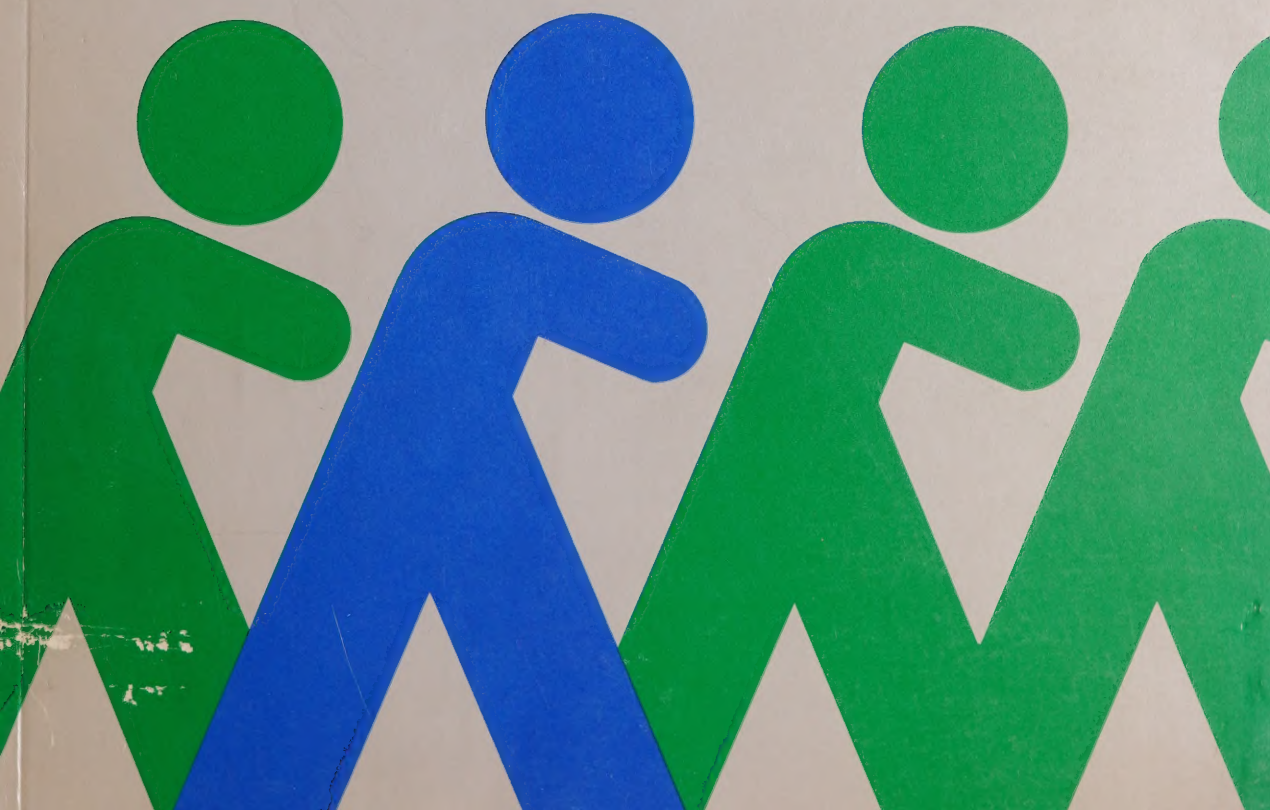

PROFESSIONAL AND TECHNICAL MANPOWER REQUIREMENTS AND SUPPLIES IN THE MICROELECTRONICS INDUSTRY IN ONTARIO : 1981-85

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HIGHLIGHTS

This report presents the findings of a series of studies on future manpower requirements and supplies for selected professional and technical occupations in the microelectronic industry in Ontario over the 1981-85 period. These studies were undertaken by the Labour Market Research Group of the Ontario Manpower Commission at the request of the Ontario's Task Force on Microelectronics. The specific question that these studies were to answer was, "will there be enough skilled manpower in Ontario to meet the requirements of the microelectronics industry between 1981 and 1985?"

For the purposes of this study, the "microelectronics" industry was defined to include the following three sectors:

1. The microelectronics and related manufacturing sector.
2. The software sector.
3. The information processing services sector.

A sample of employers in each of the above three sectors were surveyed to determine their future manpower requirements for selected professional and technical occupations.

The results of these studies show that:

1) The employment of engineers in the microelectronic industry in Ontario is projected to increase by approximately 1500 between 1981 and 1985. Most of these requirements, 1400 of the 1500, are for electrical and electronics engineers. Over this period roughly 2790 graduates from the electrical and electronic engineering programs from Ontario universities will be available to the labour market in Ontario. At present, the microelectronics industry employs roughly 12 per cent of the electrical and electronic engineers in Ontario. The projected requirements of the microelectronics industry represent roughly one-half of the total supply that would be available from Ontario universities. This would suggest that, if the requirements of the other sectors of the economy, such as utilities, continue to grow in proportion to their current

employment stock, it could be concluded that the supply of electrical and electronic engineers available from Ontario universities would fall short of meeting the projected requirements of the microelectronics industry in Ontario during the 1981-85 period.

2) The projected requirements of the microelectronics industry in Ontario are for 10,500 computer specialists during 1981-85. Over this period approximately 2570 graduates from Ontario universities in the computer science programs will be available to Ontario labour markets. Another 3250 persons with training in computer related fields of study will be available from the Community Colleges in Ontario. In other words, a total 5820 persons with training in computer related fields will be available in Ontario during 1981 to 1985. In spite of the fact that many of these computer specialists could have training in any number of other fields of study, it is very likely that shortages of experienced computer specialists could develop for certain specific functions in the industry over this period.

3) The microelectronics industry in Ontario will require an additional 2000 draftsmen, engineering technicians and technologists, and other computer related technicians over the 1981-85 period. Of these, the engineering technicians and technologists account for 1500. The number of engineering technicians and technologists available from Community Colleges in Ontario between 1981 and 1985 is projected to be approximately 3090. At present the industry employs less than 3 per cent of engineering technicians and technologists in Ontario. The projected requirements of the microelectronics industry in Ontario of 1500 engineering technicians and technologists over the 1981-85 period, represent roughly 30 per cent of the total supply of engineering technicians and technologists available from the Community Colleges in Ontario over this period. For this category of occupations, an imbalance situation very similar

to that of the engineers discussed above, might also develop. In other words, unless the other sectors employing engineering technicians and technologists have much lower requirements for engineering technicians and technologists, the supply available from the Community Colleges in Ontario would fall short of meeting the projected requirements of the microelectronics industry in Ontario over the 1981-85 period.

The answer to the question, "will there be enough skilled manpower in Ontario to meet the requirements of the microelectronics industry between 1981 and 1985", according to the results of the surveys conducted for this study is no. The results of this study suggest that the microelectronics industry in Ontario is likely to experience shortages of electrical and electronics engineers, exprienced computer specialists, and engineering technicians and technologists over the next five years.

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INTRODUCTION

This report presents the findings of a series of studies on future manpower requirements and supplies for selected professional and technical occupations in the microelectronic industry in Ontario over the 1981-85 period. These studies were undertaken by the Labour Market Research Group of the Ontario Manpower Commission at the request of the Ontario's Task Force on Microelectronics. The specific question that these studies were to answer was, "will there be enough skilled manpower in Ontario to meet the requirements of the microelectronics industry between 1981 and 1985?"

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1. The microelectronics and related manufacturing sector.
2. The software sector.
3. The information processing services sector.

A sample of employers in each of the above three sectors were surveyed to determine their future manpower requirements for selected professional and technical occupations. The following sections include a brief description of the methodology, the survey results for each of the above sectors, as well as information on the potential labour supply available from the Community Colleges and Universities in Ontario over the 1981-85 period in the selected professional and technical occupations. The final section provides an overview in terms of the imbalances between projected manpower requirements and supplies between 1981 and 1985 in Ontario.

A. THE MICROELECTRONICS AND RELATED MANUFACTURING SECTOR

In this study, only firms involved in the manufacturing of the following products and/or components thereof were included:

a) telephone and telecommunications equipment;
b) other types of communications equipment and data transmission:
c) scientific instruments;

Table 1

Growth in Total Employment
in the Microelectronics and Related Manufacturing Sector,
1975-1981

Product Line	No. of Firms Manufacturing Specified Products	Reported Employment (mid-March)		Percent Change
		1975	1981	1975-81
Telephone and Telecommunications Equipment	15	930	1,263	35.8
Communications Equipment other than Telecommunications	22	1,076	1,544	43.5
Scientific, Engineering and other Instruments	19	870	1,105	27.0
Computing Equipment	29	836	1,562	86.8
Electrical Components	29	1,122	1,567	39.7
TOTAL ALL FIRMS	53*	2,050	2,851	39.1

* Of the total 57 firms which responded, only 53 provided complete historical data.

Note also that of the 53 firms shown here, many are engaged in the manufacture of several types of products.

- Mechanical Engineering Technicians
- Chemical Engineers
- Physicists
- Chemists

The above ten selected professional and technical occupations accounted for just under 17 per cent of the total employees in the respondent firms in March 1981. The majority of employees, 59 per cent, in the respondent firms were production workers. The remaining 24 per cent of the employees were involved in clerical, administrative, management and other related functions. Among the ten selected professional and technical occupations, electrical and electronic engineers, technicians and technologists are the most prevalent and accounted for more than three-quarters of the employment in these occupations (see Table 2).

The projections for the 1981-85 period show that employment in the ten selected professional and technical occupations will increase by roughly 130 per cent between 1981 and 1985 while the employment of production workers will increase by only 75 per cent (see Table 3). For the ten professional and technical occupations, this represents an average annual rate of growth of over 32 per cent.

In addition to providing information on their projected requirements in 1985, the employers were also asked to indicate what in their opinion, considering all factors, is likely to be the minimum and maximum growth in employment at their firms. The survey results, presented in Table 4, show that for the selected ten professional and technical occupations the respondent firms expect a minimum growth of 73 per cent and a maximum growth of 177 per cent over the 1981-85 period. The range for the growth in employment of production workers is indicated to be a minimum of roughly 53 per cent and a maximum of 106 per cent.

Current Shortages

The experience in terms of hiring qualified personnel over the past twelve months vary with the occupation. Just under half of the employers recruiting for electrical/electronic engineers indicated that they experienced difficulty in recruiting. The most often cited reason, in half of the cases, was the "lack of qualified applicants with appropriate experience." Another one-quarter identified the "lack of applicants." The remaining one-quarter identified a whole host of other reasons. In the case of electronic engineering technicians and technologists, about one-third of the employers recruiting for such personnel reported recruitment difficulties. Just over 60 per cent of these employers cited the "lack of applicants

Table 2

Employment for Selected Professional and Technical Occupations in the Microelectronics and Related Manufacturing Sector, March 1981

Occupations	Establishments		Employees	
	Number Employing	Per Cent of Total	Number	Per Cent of Total
Electrical and Electronic Engineers	43	75.4	160	5.4
Electronic Engineering Technicians	39	68.4	124	4.2
Electronic Engineering Technologists	36	63.2	101	3.4
Electro-Mechanical Engineering Drafting Technicians	22	38.6	54	1.8
Mechanical Engineers	15	26.3	20	0.7
Mechanical Engineering Technologists	9	16.8	20	0.7
Mechanical Engineering Technicians	5	8.8	12	0.4
Chemical Engineers	2	4	2	0.1
Physicists	2	4	6	0.2
Chemists	1	2	3	0.1
Sub-Total Above	x	x	502	16.9
Production Workers	52	91	1,738	58.7
All Other	x	x	723	24.4
Total All Firms and Employees	57	x	2,963	100.0

Table 3

Projected Employment for Selected Professional and Technical Occupations in the Microelectronics and Related Manufacturing Sector, 1981-1985

Occupations	# of Est. Reporting	Percent Change 1981-85
Electrical & Electronic Engineers	37	132.0
Mechanical Engineers	12	61.1
Chemical Engineers	2	0
Chemists	1	33.3
Physicists	2	33.3
Electronic Engineering Technologists	33	161.1
Mechanical Engineering Technologists	9	120.0
Electronic Engineering Technicians	35	134.7
Mechanical Engineering Technicians	5	83.3
Electro-Mechanical Engineering Drafting Technicians	20	112.5
Total ten Professional & Technical Occupations	xx	130.0
Production Workers	44	75.0
TOTAL ABOVE	xx	88.7

Table 4

Projected Increase in Employment for Selected Professional and Technical Occupations in the Microelectronics and Related Manufacturing Sector, 1981-1985

Job Category	Percent Increase in Employment : 1981-85	
	Minimum Likely	Maximum Likely
10 Selected Professionals and technical occupations	73.2%	177.1%
- engineers & scientists	62.0%	166.0%
- technologists	78.0%	194.0%
- technicians	80.7%	177.8%
Production Workers	52.9%	106.3%

with appropriate experience" as the main reason. Another 22 per cent cited the "lack of applicants" in general as the reason. In the case of production workers, only one-quarter of the employers reported experiencing hiring difficulties over the last 12 months.

Sources of Supply : Professional and Technical Staff

During 1980, a total of 142 professional and technical personnel were hired by the responding firms. Slightly more than half of the newly hired (54.9%) came from other employers. The second most significant source for the newly hired was the community colleges (22.5%). Only 6.3 per cent of the newly hired came from outside Canada. A fairly low proportion (9.2%) were hired from Canadian universities (see Table 5).

In terms of the different occupations, almost two-thirds of engineers recruited by respondent firms came from other employers. Only 23 per cent of these were hired from educational institutions. On the other hand, roughly half of the technicians and technologists were hired from the educational institutions (see Table 6).

EXPERIENCE OF THE U.S. FIRMS : 1976-1981

The purpose of this activity was to investigate the experience of the U.S. firms over the 1976-81 period in terms of growth in employment and the effect of this growth on the occupational distribution of their work force.

A total of 24 firms located in the Boston, San Francisco and Los Angeles areas were interviewed. These firms were selected because they manufactured products similar to Ontario firms, i.e., electronic components, communications equipment, other communications equipment, computing equipment, and scientific equipment. Current employment in these firms, characterized by small independents to national and international conglomerates, ranges from just over 100 to over 40,000. Generally, for the 24 firms sales revenue and employment have at least doubled since 1976.

Of the 24 firms interviewed, comparable employment data for 1976 and 1981 were provided by 16 firms only. The data for the 16 firms show that the number of engineers, scientists, computer specialists, technicians, and production workers employed by these firms has more than doubled over the 1976-81 period. However, the increases vary considerably by occupation group. For example, while the number of production workers nearly doubled, the number of computer specialists employed by

Table 5

Sources of Supply for Selected Professional and Technical Occupations in the Microelectronics and Related Manufacturing Sector, 1980

	New Hires - 1980	
	Number	Percent
TOTAL	142	100.0
Other Employers	78	54.9
CAATs	32	22.5
Canadian Universities	13	9.2
Other Canadian Educational Institutions	4	2.8
From Outside Canada	9	6.3
Other Sources	6	4.2

Table 6

Sources of Supply for Engineers, Technicians and Technologists in the Microelectronics and Related Manufacturing Sector, 1980

	Source of New Hires For					
	Engineers		Technicians		Technologists	
	Total	Percent	Total	Percent	Total	Percent
TOTAL HIRED	57	100.0%	54	100.0%	31	100.0%
Other Employers	37	64.9	26	48.1	15	48.4
Educational Instit.	13	22.8	22	40.7	14	45.2
Outside Canada	5	8.8	3	5.6	1	3.2
Other	2	3.5	3	5.6	1	3.2

these firms nearly tripled over this period. This has resulted in changing the occupational composition of their work force. While in 1976, computer specialists accounted for only 3.5 per cent of the engineers, scientists, computer specialists, technicians and production workers employed, by 1981 their share had nearly doubled to 6.5 per cent. Technicians also accounted for a larger share in 1981, 21 per cent, as compared to 17 per cent in 1976. The groups whose shares declined over this period were engineers and production workers (see Table 7).

The main factors responsible for the overall employment increase for the occupations studied are growth in application of basic technology, energy conservation, increasing use of electronic components in automobiles, and growth in consumer, commercial and industrial markets. The changes in occupational composition, however, are more difficult to analyze. At the firm level, these changes are subtle and are often determined by market demands and opportunities for individual products.

The relative decline for production workers can be attributed to increased productivity, changes in product lines for"black box" standard items to large systems-based products, an ability to transfer production functions to other sites in U.S. or the world, etc. In addition, because of the increasing emphasis on support functions such as sales and service, other occupations tend to grow at a faster rate than production workers.

As might be expected, employment in the engineering group has increased in line with expansion of existing and new applications. However, their share of employment has declined somewhat since 1976 because engineers have become more productive and some engineers have been moved from the "hardware" into the "software" classification, i.e., computer specialists.

Technicians have increased their share of total employment significantly, as more and more technicians are required for service and quality control. Equally noteworthy is the fact that many companies now are forced to substitute technicians for engineers who are in short supply. In addition, requirements for technicians have continued to increase in line with the growing demand for engineers.

Computer specialists have also experienced rapid growth and their share of total emplomemt has increased from 3.5 per cent to 6.5 per cent. Computer specialists are required for both sales and service and product design functions. The latter is becoming more and more "software" oriented.

Scientists are employed by very few of these companies, and employment opportunities are highly selective depending on product lines (e.g., instruments). Presently, scientists represent less than one per cent of the studied employment.

Table 7

Changes in Employment and Occupational Distribution for Selected Professional and Technical Occupations in the Microelectronics and Related Manufacturing Sector 1976-1981

Occupational Group	Employment		Percent Change	Percent Distribution	
	1976	1981	1976-81	1976	1981
Engineers	600	1,181	+ 96.8	17.5	16.3
Scientists	22	55	+ 150.0	0.6	0.8
Computer Specialists	121	470	+ 288.4	3.5	6.5
Technicians	584	1,517	+ 159.8	17.0	21.0
Production Workers	2,101	4,003	+ 90.5	61.3	55.4
TOTAL ABOVE	3,428	7,226	+ 110.8	100.0	100.0

Basically, there has not been a change in formal educational requirements for entry into these occupations since 1976. For professional occupations, a B.Sc. degree and for technical occupations, a 2-year certificate are adequate. However, because of shortages of engineers, employers are willing to consider candidates with fewer years of experience. Some firms, in fact, prefer to hire fresh graduates so that the firms are better able to train graduates for their technologies.

The vast majority of small companies do not provide training because it is a "luxury they cannot afford." Some large corporations, on the other hand, have significant training commitments; they either have their own training facilities or hire instructors from colleges and universities to hold classes at the establishment site. Most training is still done through work and supervisory assignments. Practically all corporations encourage their employees to take professional courses for which they are reimbursed.

There is a general agreement that engineering, technician and production workers are in short supply. To increase the supply of scarce manpower, companies either undertake their own training or become active in the educational community. For example, in the Boston area, the executives of high technology firms have formed the Massachusetts High Technology Council to liaise with community schools to facilitate funding and to develop relevant curriculi. Companies in the San Francisco area, likewise, are working closely with the community college system to develop curriculi more in tune with specific company needs.

Among the many remedies that companies use to live with the shortages are: promoting the firm's image, offering employee shares in the business, building elaborate recreational facilities, appealing to individuals' professional interests and needs, providing transportation (production workers), aggressively recruiting on campuses, etc.

Occupational shortages seem to have a significant impact on the firms' competitiveness, both in national and international markets. This is manifested in two ways: a slowdown in the rate of"new product release", and inflated wage and benefit packages. In order to maintain its market share, a firm has to grow substantially. To this end, a key objective of many firms is to introduce new products every 2-3 years. Development of such products can also take up to 3 years and sometimes as long as 5 years to reach production and sales. Any slowdown in releasing new products can be critical to companies' growth and profits. Shortages of specific skills required for new product development, therefore, are critical.

Inflated wage and benefit packages can make it especially difficult for smaller firms to attract required manpower. There is fierce competition in the product market, not only on the basis of performance, but also on the basis of price which includes the high wage and benefit costs. In response to the shortages, some companies have started to subcontract all types of work ranging from highly specialized jobs requiring consultants to assembly work requiring production houses.

The U.S. firms we interviewed, were confident that their sales volumes will at least double by 1985 and that total employment will increase by at least 20 per cent per year. For the 1980's many companies are planning increasing emphasis on software engineering. One executive predicted that the engineer and the computer specialist will become one and the same by 1985 and that Senior Designers (engineers) will concern themselves more with solid state physics. Some contend that theoreticians will find it increasingly difficult to get jobs because most employers will be seeking personnel with a combination of theoretical and application skills. Generally, respondents stated that the industry must become more efficient and it must employ engineers more effectively. In the technician area, some companies are already achieving efficiencies by using CAD's (computer aided design) and automated test equipment. Other companies producing more intricate products (instruments) are hoping for a breakthrough in the utilization of diagnostic test equipment. One company official noted that while the number of devices that can be put on each wafer (microchip) has increased, there is no requirement for additional people to accomplish this. Finally, the industry is looking toward a weeding out process, i.e., the elimination of non-competitive firms. All of these trends suggest that some of the current manpower shortages may ease off in the future. However, as one company official stated, because the pace of technological advancement is not easy to predict, it is difficult to be precise about future human resource requirements.

B. THE SOFTWARE SECTOR

This section highlights the major findings of two field surveys conducted among 18 software firms in Ontario and 5 comparable firms in the United States.

The primary purpose of these surveys was to obtain from Ontario firms information on their current and future occupational manpower requirements and staff shortages and, whenever possible, to assess this information in the context of the U.S. firms' past experiences with the recruitment and utilization of their software specialists during the 1976-81 period.

Definitions and General Occupational Characteristics

For the purpose of this report, the term "software" refers to a set of logical instructions guiding either (a) the internal operations of a computer, or microelectronic component "Systems Software" or (b) directing the external functioning of a computer in a variety of industrial and business applications ranging from comuterized information systems to computer model "Applications Software" manufacturing.

In general, systems software requires a higher level of engineering skills than does applications software. Systems software specialists are required to have a more detailed knowledge of computers or microelectronic devices calling for a theoretical background usually gained through a directly-related university education, such as electronic engineering. On the other hand, the applications software specialist usually works with existing computer hardware systems and should have detailed knowledge of the specific functional areas such as finance or manufacturing in which a computer system has to be implemented.

Although the skills required are less technical in nature, the applications specialist must have the same logical and conceptual capabilities as the systems specialist. In addition, he/she should possess communications and interpersonal skills to facilitate the consultative work with external clients which can comprise a major part of applications software development.

Although a variety of occupations can be found in the software development field, the area is dominated by computer-specialist occupations, particularly systems analysts, computer programmers, and programmer/analysts. Because of its hardware orientation, the systems software field also includes electronic and computer engineers as well as their supporting technicians and technologists. The customer focus of the applications area is reflected in a number of specialized customer support and marketing occupations in the computer software sector. The application of computers to manufacturing operations also requires specialized occupational skills such as process control engineers, sophisticated electronics maintenance personnel and programmers with machine tool experience.

METHODOLOGY

The methodology used for determining the future manpower requirements for this sector consisted of:

a) Conducting a survey of a sample of firms in Ontario to determine their current and projected manpower requirements for selected and technical occupations, and

b) Interviewing a small sample of comparable firms in the U.S. to find out what has been the impact of implementing new software/hardware technologies on the employment level and the occupational mix of these firms over the 1976-1981 period.

The results of the survey of the Ontario firms and the sample of U.S. firms are presented below:

ONTARIO FIRMS

According to industry experts contacted during this survey, there are approximately 12 companies (mainly branches of multinational corporations) manufacturing either electronic data processing equipment (computers in various sizes) or components for EDP equipment in Ontario. Eight of these manufacturers, considered to be the principal and perhaps the only developers of systems software in Ontario were included in the survey sample. The number of independent (from hardware manufacturers) specializing largely in software development in Ontario is estimated to be less than one dozen. These organizations, called "software houses" should not be confused with the hundreds of computer service bureaus, management consultants, hardware vendors and the like who may develop and/or sell software as some part of their other activities. The survey sample included six software houses. They deal exclusively in applications software. In addition, leading Ontario companies involved in CAM techniques were interviewed. In-depth personal interviews with the representatives of these firms were conducted during March and April, 1981 to obtain information on their current and projected manpower requirements, shortages, sources of supply and potential bottlenecks.

Current and Projected Manpower Requirements

The six software houses that were interviewed employed 593 persons in computer related occupations in the software development area in March, 1981. (See Table 8). Approximately 50 per cent (287) of these are computer programmers, and 28 per cent (167) are systems analysts. In terms of their future manpower requirements these firms have indicated a phenomenal growth. The survey results show that employment in practically every occupation will double between 1981 and 1983. In 1985, these firms indicated that they will be employing three times as many people as they do now in software development activities. Again, the increase is perceived to be across the board for all occupations.

Table 8

Current and Projected Employment For Selected Professional and Technical Occupations In Software Houses, 1981, 1983 and 1985

Occupation	Current Employment	Projected Employment	
	1981	1983	1985
Systems Analyst	167	314	488
Computer Programmer	287	565	857
Computer Installers/Repairers	1	3	5
Computer & Peripheral Operator	1	2	3
Other Computer	137	255	375
Sub-total Computer Related	593	1,139	1,728
Mechanical Engineer	1	3	5
Industrial Engineer			
Computer/Electronic Engineer	4	10	16
Electrical Engineer			
Other Engineer	4	7	12
Sub-total Engineers	9	20	33
Mathematician			
Physicist			
Chemist			
Other Scientists			
Sub-total Scientists	0	0	0
Draftsman	2	5	8
Mechanical Engineer:Technician	2	5	8
Mechanical Engineer:Technologist	1	2	3
Electronic Engineer:Technician	1	3	6
Electronic Engineer:Technologist	3	6	9
Electricl Engineer:Technician			
Electrical Engineer:Technologist			
Sub-total Engineering Technicians	9	21	34
*TOTAL	611	1,180	1,795

*Data presented in this table are based on 5 software houses only, for which statistical projections were available.

In terms of functional area, just over half of the computer specialists, i.e. systems analysts, computer programmers and other computer-related professionals employed in the software houses, are involved in design and implementation activities. About one-quarter are involved in consulting activities. Of the remaining one-quarter, half are involved in research and development and the other half in sales, customer services and administration. No major shifts in this functional breakdwon are projected during the 1981-85 period.

In the software development area, the eight computer hardware manufacturers that were interviewed currently employ 1,044 persons in computer-related occupations, 961 engineers, 500 engineering technicians and 85 scientists. (See Table 9). Among the computer-related occupations, the vast majority, over 86 per cent, are systems analysts, programmer/analysts, and computer programmers. The remaining, under 14 per cent, are employed as computer installer/repairers, computer and peripheral operators and in other computer support areas. In the engineering category, of the 961 engineers, 82 per cent are electrical and electronics engineers, 7 per cent are mechanical engineers, 3 per cent are industrial engineers and 8 per cent are software engineers. Among the engineering technicians and technologists, roughly three-quarters are electrical and electronic technicians and technologists. The remaining one-quarter are employed as draftsmen.

Employment growth for the eight computer hardware manufacturers is projected to be much lower than for the software houses. While the software houses indicated that the number of persons they employ in computer-related occupations would triple between 1981 and 1985, the hardware manufacturers indicated a growth of less than 50 per cent in these occupational categories over this period.

In terms of functional area, approximately 30 per cent of the computer specialists in the manufacturing companies are employed in each of the research and development, and design and implementation areas. About one-quarter are employed in sales and customer service, and only a small percentage in consulting and administration. Over the 1981-1985 period, the proportion engaged in research and development activities is projected to increase substantially from 34% to 48%, while those engaged in design and implementation activities will decline from 30% to 23%.

In terms of specific occupations, the eight hardware manufacturers indicated a growth of 40 per cent in employment for engineers and roughly 30 per cent for scientists, engineering technicians and technologists over the 1981-85 period.

Most employers feel that the demand for qualified personnel will continue to grow in the future as an increasing amount of software will be required to service

Table 9

Current and Projected Employment For Selected Professional and Technical Occupations in the Hardware Manufacturing Sector, 1981, 1983 and 1985

Occupation	Current Employment	Projected Employment	
	1981	1983	1985
Systems Analyst, Programmer/ Analyst[1] Computer Programmer[1]	902	1,060	1,270
Computer Installers/Repairers	142	162	182
Computer & Peripheral Operator	34	42	55
Other Computer	10	15	20
Sub-total Computer Related	1,044	1,279	1,527
Mechanical Engineer	70	59	63
Industrial Engineer	30	33	45
Computer/Electronic Engineer[2]			
Electrical Engineer[2]	784	981	1,152
Other Engineer	77	77	88
Sub-total Engineers	961	1,150	1,348
Mathematician			
Physicist			
Chemist			
Other Scientists			
Sub-total Scientists[3]	85	95	110
Draftsmen	75	77	86
Mechanical Engineer: Technician	3	4	5
Mechanical Engineer: Technologist	2	3	4
Electronic Engineer: Technician[4]			
Electronic Engineer: Technologist[4]			
Electrical Engineer: Technician[4]	210	240	295
Electrical Engineer: Technologist[4]			
Sub-total Engineering Technicians[5]	500	554	660
* TOTAL	2,590	3,078	3,645

* Data presented in this table are based on 8 hardware manufacturers.

1 some companies grouped these three occupations together
2 some companies grouped both of these occupations together
3 a complete breakdown for these occupations was not given
4 some companies grouped all of these occupations together
5 one company gave total figures only

the proliferation of computers penetrating all aspects of society. Certainly the demand for systems software specialists (be they systems analysts, computer programmers, electronic engineers or computer/systems engineers) will continue to increase. However, some employers feel that as the production and sale of standardized software "packages" become more widespread, and as these packages become more sophisticated and universal in nature, the demand for applications personnel (systems analysts and computer programmers) may level off, and even decline.

Current and Projected Shortages:

The employers interviewed indicated that they have been experiencing serious problems recruiting systems analysts, computer programmers, electronic engineers and computer/systems engineers. Employers anticipate that supply will continue to fall short of the rising demand in both the short-term and medium-term future for occupations in which shortages are currently being experienced because of the perceived lack of persons currently training for the occupations. However, if the demand for applications software does indeed level off as predicated by some employers, the shortfall for applications programmers and analysts may not materialize.

This general shortage of qualified personnel has constrained growth in the software industry in varying degrees. In some cases new business contracts were turned down or work was contracted out where possible.

Sources of Supply and Potential Bottlenecks

Because experienced personnel are at a premium in both systems and applications work, some employers have found it necessary to recruit overseas, to "raid" other employers, either directly or indirectly (through agencies), or to offer incentives to their employees to bring in referrals.

Graduates of the University of Waterloo's cooperative program are highly sought after among new university graduates: the combination of a theoretical training and practical experience in industry offered in such a co-op program gives them a distinct advantage over other graduates. Because employers recruit largely from universities and community colleges to meet rising demand, they must provide considerable training to supplement the purely theoretical background of most graduates. This training can range from formal classroom work to very informal on-the-job training. Employers find that training entails considerable direct and indirect costs.

Because applications software development requires minimal hardware knowledge, software houses do not necessarily need computer science graduates. They can train capable people from other disciplines (particularly business and commerce graduates) in computer languages and develop them into qualified applications software personnel. Hardware manufacturers, with their emphasis on systems software, do need graduates with computer science or electronics engineering backgrounds. Again, these graduates would need specific training in the manufacturer's particular hardware.

Employers were concerned that because educational institutions do not offer benefits to highly qualified personnel that private industry can, the universities could lose their top faculty members to industry which will slowly erode the base for educating the future supply of qualified personnel. In addition, employers were concerned that although the interest in this field by students entering higher educational institutions is currently growing, this supply will still be less than what they will need when the students graduate. Non-traditional sources of personnel for this field (such as women, handicapped persons, retirees and high school graduates) may be tapped in the future.

EXPERIENCE OF THE U.S. FIRMS 1976-81

The purpose of this activity was to determine what has been the experience of the U.S. firms over the 1976-81 period in terms of: growth in total employment and volume of sales, the impact of growth on the occupational composition of their work force, manpower shortages experienced by these firms and the strategies adopted by these firms to deal with shortages.

To obtain this information, in-depth personal interviews were conducted with the executives of five semi-conductor and computer software firms in the Boston-Cambridge area and the "Silicon Valley" region of California. Four of the five firms interviewed have more than doubled in terms of total employment and volume of sales during the 1976-80 period. Some of the major factors contributing to this growth include:

a) Rapidly expanding markets for more versatile, or "intelligent" terminals, micro/minicomputers, or other specialized electronic devices, calling for increasing sophistication in the design of more complex microprocessor-based systems for industrial, consumer, or military applications;

b) Increasing sophistication in the design of more complicated logic circuits and their incorporation into a single silicon chip (i.e. making microchip more "intelligent" through Very Large Scale Integration;

c) Competitive pressure on improving the cost-efficiency of the microchip design and manufacturing, calling for increasing sophistication in the design of computer software or hardware systems for use in the design and manufacturing of integrated circuits including computer-assisted design and manufacturing (CAD & CAM).

d) Rapidly increasing demand for wider application of microelectronics technology in all sectors of the economy, ranging from telecommunications to home entertainment systems.

e) Increasing use of software specialists in sales and service functions as a means of assisting the increasingly sophisticated clients in their design or application problems.

The rapid growth in employment has not significantly altered the occupational composition of the work force. In other words, increases have been constant for all major occupational groups. Also, while overall growth of the work force in these firms is expected to triple or even quadruple over the 1981 to 1985 period, no shifts are expected between major occupational groups. However, there may be changes in the skill or experience requirements for some specific occupations within a broad occupational group attributable mainly to the introduction of new product lines.

There is strong consensus that there are critical shortages of experienced software professionals in the United States, particularly those with specialized knowledge of microprocessor-based systems or of a particular language or of a specific computer series. This shortage appears to be more severe for those specialists who, through a balanced expertise in both hardware (e.g. electronics) and software - (e.g. computer sciences) could best design and implement optimally - integrated software-hardware systems ranging from small microchip driven equipment to major multimillion dollar computer-based intelligence systems.

Some of the more specific reasons given for the shortage of software specialists include: inadequate domestic supply of new graduates in electronic/electric engineering, computer sciences or in closely related scientific disciplines such as solid state physics; mismatch between the specific entry-level skill requirements of semi-conductor producers or software design firms and the academic

curriculi in the technical colleges or universities, partly due to lack of a continual dialogue between the employers and academic community; mismatch between the work experience required by the employers for their unique products, services or processes, and the candidates' previous work experience in these areas; waning of interest in engineering and hard sciences among the American youth following the Vietnam war and winding down of major space exploration projects; regional shortage of manpower supply in California partly caused by higher regional living costs, opening up of high technology industrial centres throughout the United States, such as Houston or Florida, and more restrictions in the U.S. immigration laws.

In response to current shortages, most of the firms have adopted a number of short-term and long-term strategies. Short-term strategies include such personnel policies as: offering profit-sharing plans, increasing salaries, establishing in-house search teams and referral bonuses, establishing closer linkages with the government and neighbouring universities and colleges to develop co-operative programs. As part of their long-term strategy for dealing with the shortage of experienced software professionals, as well as for competitive reasons, most of the semi-conductor firms are introducing such technological innovations as transplanting more of their software programs into silicon chips, or "firmware" packages which can in turn be readily combined in modular fashion to create more complex software systems for a variety of applications. Although these technological innovations are in the early stages of development, they are already proving highly promising in partially alleviating the critical shortage of software specialists, particulary in the semi-conductor industry. As stated by one of the executives interviewed, "Software designers are hard to find and expensive, and are slowing down industry growth. Firmware, on the other hand, can be mass-produced." It is generally believed that the advent of modular firmware, and the increasing use of computer-aided software design, many reduce the future demand for most categories of software specialists, and could bring about significant reductions in the cost of software development.

C. THE INFORMATION PROCESSING SERVICES SECTOR

For the purposes of this study, information processing personnel are defined to consist of employees who are working in firms that provide information processing services to primary end-users. These users (whether own firm or client firm) have some degree of control over the nature, purpose, and scope of the system. The information processing services include the systematic collection, processing, storage, retrieval, and delivery of information for application by end-users.

The approach used for determing the future manpower requirements for this sector involved:

a) conducting a survey of firms involved in "information processing" to determine their current and projected manpower requirements;
b) using a delphi-type approach to assess the impact of the introduction of micro-processing technology on employment in the sector;

The results of the survey of a sample of Ontario firms and the results of the delphi-type study to provide a qualitative assessment of the changing demand for computer services personnel are presented below:

ONTARIO FIRMS

The purpose of this activity was to determine the trends in employment over the 1981-85 period in selected professional and technical occupations employed in the information processing services sector. A random sample of 45 employers, who have EDP equipment with a monthly rental cost of over $20,000, was selected.[1] In terms of the industrial breakdown, government and manufacturing each accounted for 24 per cent of these employers, 20 per cent from insurance, education and service bureaus each accounted for 8 per cent.

These 45 employers were asked to provide information on their current and projected employment levels to 1985 for the following fifteen occupations:

Managers/Supervisors
Senior Analysts
Junior Analysts
Senior Programmers
Junior Programmers
Senior Programmers/Analysts
Junior Programmers/Analysts
Senior Methods/Procedures Analysts
Junior Methods/Procedures Analysts
Senior System Software Programmers

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[1]This is not a representative sample of the universe of firms involved in this sector.

Junior System Software Programmers
Senior Systems Engineer/Consultants
Junior Systems Engineers/Consultants
Senior Computer Operators
Junior Computer Operators

The 45 firms surveyed employed about 90,000 workers as of February 1981. Of these, only about 1,800 or 2 per cent were employed in the fifteen occupations listed above.

The survey results for these firms show (see Table 10) that employment in the fifteen occupations grew by 13.6 per cent between 1979 and 1980 and by 9.8 per cent between 1980 and 1981. It is projected to grow at an average annual rate of 5.3 per cent between 1981 and 1985. The survey results for these firms would suggest that the rate of growth for the information processing services sector will be much lower than those projected for the hardware manufacturing and the systems software sectors.

In terms of specific occupations, those that will experience above average rates of growth are: programmers, programmer/analysts, and methods/procedures analysts; while managers/supervisors, systems engineers/consultants and computer operators will experience below average growth.

Current Shortages

Only one-quarter of the firms surveyed indicated experiencing any hiring difficulties. These related mostly to recruitment of senior professionals, such as, senior analysts, senior programmer/analysts, and senior systems software programmers.

Sources of Supply

About 42 per cent of the personnel hired in the fifteen occupations by these firms were from other companies. The remaining were hired from high schools, community colleges, and the universities. The main source in the education system is the community colleges that provided roughly 30 per cent of the personnel hired in these occuptions. Another 19 per cent were hired from universities, and about 19 per cent from high schools.

Current and Projected Employment For Selected Professional and Technical Occupations in Information Processing Firms, 1979, 1980, 1981 and 1985

	Actual & Projected Employment				Percentage Change in Employment			
	1979	1980	1981	1985	1979-80	1980-81	1981-85	Average per year 81-85
Managers/Supervisors	205	246	277	297	20.0%	12.6%	7.2%	1.8%
Senior Analyst	155	184	205	253	18.7%	11.4%	23.4%	5.8%
Junior Analyst	115	127	132	159	10.4%	3.9%	20.4%	5.1%
Senior Programmer	171	205	215	280	19.9%	4.8%	30.2%	7.5%
Junior Programmer	199	226	242	302	13.6%	7.0%	24.7%	6.2%
Senior Programmer/ Analyst	78	89	119	184	14.1%	33.7%	54.6%	13.6%
Junior Programmer/ Analyst	51	63	66	84	23.5%	4.7%	27.2%	6.8%
Senior Methods/ Procedures Analyst	19	23	34	48	17.4%	47.8%	41.1%	10.2%
Junior Methods/ Procedures Analyst	11	12	16	27	9.1%	33.3%	68.7%	17.1%
Senior System Software Programmer	58	64	72	91	10.3%	12.5%	26.3%	6.6%
Junior System Software Programmer	16	18	23	26	12.5%	27.7%	13.0%	3.2%
Senior Systems Engineer/ Consultant	15	15	18	19	0 %	20.0%	5.5%	1.3%
Junior Systems Engineer/ Consultant	13	14	13	14	7.7%	- 7.1%	7.6%	1.9%
Senior Computer Operator	196	206	221	230	5.1%	7.2%	4.0%	1.0%
Junior Computer Operator	139	145	146	169	4.3%	0.6%	15.7%	3.9%
TOTAL	1,441	1,637	1,799	2,183	13.6%	9.8%	21.3%	5.3%

A QUALITATIVE ASSESSMENT OF THE IMPACT OF MICROPROCESSING TECHNOLOGY ON THE EMPLOYMENT OF EDP PROFESSIONALS

In addition to surveying a sample of employers in the information processing services sector, it was felt that it would be useful to carry out a delphi-type study to identify the impact that the emerging technology may have on the skill-mix of the workforce in this sector. The main concern was that the respondents to the manpower requirements survey would identify their future needs by extrapolating forward the needs for existing, traditional types of personnel only. Consequently, any effect that the new technology may have on the skill mix would not be captured.

The approach used for analysis consisted of:

a) a panel discussion with six experts in the computer industry to identify the issues which should be focused upon in this study and the way the questions should be posed. A questionnaire was developed based on this discussion;

b) the questionnaire was then sent to 36 industry experts for their opinion. Twenty-nine of these experts responded to the questionnaire.

The purpose of the panel discussion was to resolve the issues which should be focussed upon, and the way the questions should be positioned. A questionnaire was developed based on the panel discussion and pre-tested. The first question revolved around the issue of whether the new generation of highly sophisticated equipment would place higher demands for design and development professionals at the application end (e.g., systems design) or would the demand shift to or be concentrated at the equipment manufacturers level.

The second question dealt with the future demand for analysts and programmers, and specifically whether the sophisticated features of new equipment such as Robotics would do away with the need for this occupational group beyong the simplest operational level.

The third question, underscoring the speculative nature of the first two questions, was a more specific articulation of the basic issue whether there will be any significant demand at all for "traditional computer personnel in the process control and word processing functional areas".

The question of "Traditional Data Processing" occupations was followed more specifically by presenting a series of three scenarios in the fourth question. The scenarios which were to be rank-ordered by the respondents put forth the proposition that:

a) because of the future availability of pre-programmed "packages" the total demand for programmers will decrease
b) because of the widespread availability of micro and mini-computers the jobs of analysts and programmers will become increasingly decentralized in terms of physical location, although the total demand for these occupations will not decrease, and conversely
c) because of the widespread availability of and access to low cost information, the "appetite" for more information may grow resulting in an increase in the total demand for computer professionals.

The fifth question asked for industry expert opinion about the likelihood of a new type of computer professional emerging in the future. The question was stated as follows; "one possible consequence of microchip technology is that not only may the number and mix of computer professionals change, but also the types of computer personnel may be affected. Functional specialists such as accountants or business analysts who spend some time modifying and running applications software, or "firmware", may become commonplace".

In an attempt to get an approximate indication of the scope of future demand, the sixth question asked the respondents to indicate their expectation of demand for seven types of computer professionals on a scale of 1 to 5 ranging from "Far Fewer" to "Far More".

The final (seventh) question asked the respondents to indicate whether they expected a demand for further or emerging types of computer professionals which have not been specifically noted in the questionnaire.

The questionnaire was sent to the 36 industry experts. Based on their responses to these questions, a number of conclusions which reflect what the respondents think will happen were formulated. These are:

1. Most experts anticipate that there will be an overall increase in demand for most computer professionals by 1986.

2. There is a generally-held opinion that low-cost computing will lead to the proliferation of computers and computer-controlled systems. That situation in turn will spawn an industry demand for more professionals, which will not abate by 1986.

3. Respondents believe that there is a high probability that there will be a demand for more — up to twice as many — systems analysts and programmers by 1986.

4. There is also a strong expectation that an emerging type of computer professional will become commonplace. This professional type will be a functional specalist who also spends a significant portion of his/her time with a computer. The number of these types, compared to the present, could be well over double.

5. It is generally believed that other computer professionals — software programmers, operators, maintenance personnel — will increase somewhat. Opinion suggests the demand will lie somewhere above current demand, but not likely as much as double the present requirement.

6. It is generally thought that demand will decline a little (but not as much as half) for data entry and data control clerks.

7. There is a fairly consistent opinion that there will be a number of new types of personnel on the scene by 1986. Some of these include communications personnel, interface analysts, security specialists and EDP consultants.

8. There is not clear agreement about the future capability and sophistication of work processing and process control devices. Consequently among many experts there is some uncertainty about the future personnel requirements for those devices

D. MANPOWER REQUIREMENTS IN THE MICROELECTRONICS INDUSTRY IN ONTARIO: 1981-85

Based on the results of the surveys presented in the preceding sections, an attempt was made to generate estimates of the manpower requirements for the microelectronics industry in Ontario over the 1981-85 period. In order to generate these projections, it was necessary to make some assumptions about the proportion that the sample represented of the universe of firms in each sector. It should be noted that the projections presented in this section are only a rough estimate. The errors in these estimates can arise for numerous reasons. The most important of which relate to assumptions about the proportion that the sample represents of the universe, as well as the representativeness of the sample to the universe.

The assumptions made about the proportions that the sample represent of the universe in each sector are as follows:

Sector		Sample as a % of Universe
Microelectronics and Related Manufacturing:		25%
Software:	Software houses:	50%
	Software-related to Computer Manufacturing:	75%
Information Processing Services Sector:		10%[1]

Based on the above proportions, the sample survey data was procurred to generate estimates of employment in selected professional and technical occupations for the year 1981.

In the case of the Information Processing Services Sector, the initial estimate of employment for 1981 pertained to large installations with a rental value of more than $20,000 per month. However, there are also an additional 4300

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[1]The sample represents approximately 10 per cent of the installations with a rental cost of more than $20,000 per month. There are an additional 4300 installations with a rental cost of less than $20,000 per month.

installations with a monthly rental cost of less than $20,000. According to the information available from secondary sources, the average number of systems and operations personnel employed per installation varies considerably by the size of the installation.[2] For example, large installations (monthly rental cost more than $50,000) employed an average of 61.3 computer professionals in 1978. The medium size installation (monthly rental cost between $5,000 - 49,900) employed 10 persons and smaller installations (less than $5,000 per month) employed only 1.7 persons. Our survey data show an average of 40 computer professionals are being employed at installations with a monthly rental cost of more than $20,000, which appears to be in the range indicated by earlier studies. For the purposes of this study and based on the data available from other sources, we have assumed that the other 4300 installations with a monthly rental cost of less than $20,000 employ on the average roughly 4 computer related professionals per installation. This means that there are roughly 18,000 computer related professionals employed at these installations. The estimated employment in 1981 for the larger installations (monthly rental cost more than $20,000) was also about 18,000. This means that the Information Processing Services sector employed roughly 36,000 computer related professionals in 1981 in Ontario. For the purpose of this study we have assumed that the occupational composition in the 4300 installations with a monthly rental cost of less than $20,000 is the same as for larger firms for whom we have the survey data.

The estimated employment in the selected professional and technical occupations for 1981 in the three sectors of the microelectronics industry in Ontario that we surveyed is presented in Column (2), of Table 11. The employment projections for 1985 presented in Column (3), Table 11 were obtained by:

1. estimating employment for 1981 by occupation in each sector;
2. applying the growth rates for the 1981 - 1985 period indicated by the survey results to the 1981 (estimated) employment in each occupation and sector;
3. the projected total employment for 1985 for an occupation was then obtained by aggregating the results for the three sectors.

The data presented in Table 11 show that between 1981 and 1985 the microelectronics industry in Ontario will require an additional:

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[2] Canadian Computer Census: 1980, Canadian Information Processing Society, p. 13.

- 1500 engineers, most of whom (1400) are electrical and electronics engineers;
- 2000 technicians and technologists, roughly three-quarters of whom are electronic technicians and technologists;
- 10,500 computer specialists, roughly three-quarters of whom are system analysts and/or programmers.

E. PROJECTED POTENTIAL LABOUR SUPPLY IN SELECTED PROFESSIONAL AND TECHNICAL OCCUPATIONS

The data on the number of persons graduating from Ontario Universities and Community Colleges by degree levels in the engineering and computer science fields over the 1981-85 period are presented in Table 12. It also includes a projection of the number of graduates who could be potentially available to the labour force in Ontario.

These data show that over the five academic years 1981 to 1985, approximately 2880 persons will graduate from Ontario Universities with an undergraduate certificate/diploma, Bachelors, Masters or a Ph.D. degree in the field of electrical and elecronic engineering. Of these, approximately 2790 could be potentially available to Ontario's labour markets. Another 2860 persons would be graduating from the Computer Sciences field over this period. The number of Computer Sciences graduates who could be potentially available to Ontario labour markets is estimated to be 2570 over the 1981-85 period.

The number of persons who would be completing the electronic and mechanical engineering technicians and technologists programs offered by the Community Colleges in Ontario is estimated to be 3830 over the 1981-85 period (See Table 12). Of these approximately 3090 could be potentially available to Ontario's labour markets over this period. Another 3930 persons would be completing training as systems analysts, computer programmers and in other computer related occupations. The number of persons who could be potentially available to the labour force in Ontario who would have completed training in the Community Colleges as systems analysts, computer programmers and in other related occupations over the 1981-85 period is estimted to be 3250.

Table 11

Estimate of Current and Projected Employment
in Selected Professional and Technical Occupations:
Microelectronics Industry in Ontario

Occupation	Estimated Employment 1981	Projected Employment 1985	Growth in Employment 1981-85
ENGINEERS: Total	2,000	3,500	1,500
Electrical & Electronic	1,700	3,100	1,400
Mechanical	200	200	(a)
Industrial	(a)	(a)	(a)
Other	100	100	(a)
SCIENTISTS: Total	200	200	(a)
Mathematicians	(a)	(a)	(a)
Physicist	100	100	(a)
Chemist	(a)	(a)	(a)
Other	(a)	(a)	(a)
COMPUTER SPECIALISTS: Total	38,400	48,900	10,500
Manager/Supervisor	5,600	6,000	400
System Analyst, and Programmer	18,000	24,300	6,300
Analyst/Programmer	3,700	5,400	1,700
Systems Software Programmer	1,900	2,300	400
Methods/Procedures Analyst	1,000	1,500	500
Systems Engineer	600	700	a
Computer Operators	7,400	8,100	700
Other Computer Specialists	300	800	500
TECHNICIANS & TECHNOLOGISTS: Total	2,100	4,100	2,000
Draftsman	300	600	300
Electronic Engineering Technician & Technologist	1,200	2,600	1,500
Mechanical Engineering Technician & Technologist	100	300	200
Computer Related Technician	500	600	100
TOTAL: All above	42,700	56,700	14,000

The estimated employment for 1981 is a rough estimate. It is based on a number of assumptions regarding the ratios that the sample population represents of the Universe of firms in each sector.

These estimates have been rounded to the closest hundred. 'a' represents estimates of less than 100. The figures may not add up due to rounding.

Table 12

Estimate of Potential Labour Supply in Selected Professional and Technical Occupations Available From Ontario's Education System: 1981-85

	Total Grads 1981-1985	Grads Available to Labour Force 1981-1985
ONTARIO UNIVERSITIES		
Electrical and Electronic Engineers: TOTAL	2,880	2,790
Bachelors	2,190	2,130
Undergrad Certificate and Diploma	350	330
Masters	280	270
Ph.D.	60	60
Mechanical Engineers: TOTAL	2,540	2,460
Bachelors	2,190	2,130
Undergrad Certificate and Diploma	160	150
Masters	160	150
Ph.D.	30	30
Industrial Engineers: TOTAL	650	630
Bachelors	390	380
Undergrad Certificate and Diploma	140	130
Masters	50	50
Ph.D.	70	70
Computer Science: TOTAL	2,860	2,570
Bachelors	2,450	2,240
Undergrad Certificate and Diploma	60	60
Masters	290	210
Ph.D.	60	60
ONTARIO COMMUNITY COLLEGES		
Draftsmen	1,120	820
Electronic and Mechanical Engineering Tech. & Tech.	3,830	3,090
Systems Analysts, Computer Programmers & Rel. Occup.	3,930	3,250

F. IMBALANCES BETWEEN PROJECTED MANPOWER REQUIREMENTS AND SUPPLIES

The projected manpower requirements in the selected professional and technical occupations employed in the microelectronics industry were presented in Table 11. The potential labour supply available from the Universities and Community Colleges in Ontario in the related fields of study is presented in Table 12. A brief analysis of the imbalances between projected manpower requirements and supplies by occupation is given below. This analysis is based on the assumption that the semiconductor industry in the United States, which is experiencing severe staff shortages, will not attract a significant number of professional and technical personnel from Ontario.

Engineers

The employment of engineers in the microelectronic industry in Ontario is projected to increase by approximately 1500 between 1981 and 1985. Most of these requirements, 1400 of the 1500, are for electrical and electronics engineers. Over this period roughly 2790 graduates from the electrical and electronic engineering programs from Ontario Universities will be available to the labour market in Ontario.

According to the Association of Professional Engineers of Ontario there are roughly 14,700 electrical and electronic engineers in Ontario. Of these approximately 1700 are employed in the microelectronics industries in Ontario. This means that the microelectronics industry employs roughly 12 per cent of the electrical and electronics engineers in Ontario. The projected requirements of the microelectronics industry during 1981-85 are for 1400 electrical and electronics engineers, which represents 50 per cent of all electrical and electronics engineers available from Ontario Universities. This would suggest that the microelectronics industry would be able to meet its needs only if the other sectors of the economy that employ electrical and electronic engineers have much lower requirements. On the other hand, if the requirements of the other sectors of the economy, such as utilities, continue to grow in proportion to their current employment stock, it could be concluded that the supply of electrical and electronic engineers available from Ontario Universities would fall short of meeting the projected requirements of the microelectronics industry in Ontario during the 1981-85 period.

Scientists

The projected requirements for scientists in the microelectronics industry in Ontario are not reported to be significant.

Computer Specialists

The projected requirements of the microelectronics industry in Ontario are for 10,500 computer specialists during 1981-85. Over this period approximately 2570 graduates from Ontario Universities in the computer science programs will be available to Ontario labour markets. Another 3250 persons with training in computer related fields of study will be available from the Community Colleges in Ontario. In other words, a total 5820 persons with training in computer related fields will be available in Ontario during 1981 to 1985. However, it is important to note that many of these computer specialists could have training in any number of fields of study. In other words if there is a steady flow from other disciplines into this field then the projected requirements could be met. This may require, however, a more intensified effort on the part of employers to provide on-the-job training to new entrants in this field. Nevertheless, it is very likely that shortages of experienced computer specialists could develop for certain specialized functions in the industry over this period.

Engineering Technicians and Technologists

The microelectronics industry in Ontario will require an additional 2000 draftsmen, engineering technicians and technologists, and other computer related technicians over the 1981-85 period. Of these, the engineering technicians and technologists account for 1500. The number of engineering technicians and technologists available from Community Colleges in Ontario between 1981 and 1985 is projected to be approximately 3090.

The Ontario Association of Certified Engineering Technicians and Technologists has a current membership of about 10,000. They estimate that their membership represents anywhere from one-third to one-tenth of the engineering technician and technologist population in Ontario. If we assume that their membership is one-fifth of the technician's and technologist's population in Ontario, then the estimated number of engineering technicians and technologists in Ontario will be 50,000. The microelectronics industry in Ontario employed approximately 1,300 engineering technicians and technologists in 1981. This means that this industry employed less than 3 per cent of the engineering technicians and technologists in Ontario in 1981.

The projected requirements of the microelectronics industry in Ontario of 1500 engineering technicians and technologists over the 1981-85 period, represent roughly 30 per cent of the total supply of engineering technicians and technologists available from the Community Colleges in Ontario over this period. For this category of occupations, an imbalance situation very similar to that of the engineers discussed above, might also develop. In other words, unless the other sectors employing engineering technicians and technologists have much lower requirements for engineering technicians and technologists, the supply available from the Community Colleges in Ontario would fall short of meeting the projected requirements of the microelectronics industry in Ontario over the 1981-85 period.